Modeling Failure of 3D Fiber Reinforced Foam Core Sandwich Structures with Defects Using a Multi-Scale Finite Element Method

Completed Technology Project (2011 - 2015)

Project Introduction

Many structures designed today including spacecraft and launch vehicles utilize sandwich composites as primary structures. Current interest surrounds the engineering of these structures with the ability to tolerate damage with significant interest in the development of new core materials. One class of core material being considered may alter their damage tolerance through the use of a three-dimensional, truss-like network of reinforcing fibers inside a lightweight foam core. This truss structure provides added paths for load transfer and acts to impede crack propagation within the foam. This research plan proposes to quantify the damage tolerance of 3D Fiber Reinforced Foam Core (3DFRFC) sandwich composites and develop a multi-scale finite element method to simulate the failure of three-dimensionally reinforced sandwich composites. The proposed research will be accomplished through the fabrication, non-destructive evaluation, and testing of 3DFRFC sandwich composites with and without defects to attain, experimentally, the effects of defects on the failure of the composites. Subsequent efforts will introduce failure modeling within the computational package ABAQUS by modeling the fracture of standard foam core sandwich composites and extending the model to the detailed microstructure of the 3DFRFC sandwich composite. Finally, implementation of the multi-scale behavior of the 3DFRFC will be introduced into the failure model. Results of both modeling phases will be compared to available experimental results. Currently, there is no ability to simulate and accurately predict the failure of the three-dimensionally reinforced foam core sandwich structures with defects, a critical ability necessary for the utilization of 3DFRFC sandwich composites as primary structures for launch vehicles and spacecraft. This proposed research has the goals of developing, implementing, and validating a modeling technique that will address this need. The outcomes of this research will provide the critical understanding and engineering tools required to fully exploit the benefits of advanced three-dimensionally reinforced sandwich structures in current and future spacecraft and launch vehicles, while having transformative impacts to the ability to utilize advanced materials in commercial aerospace and non-aerospace applications.

Anticipated Benefits

Currently, there is no ability to simulate and accurately predict the failure of the three-dimensionally reinforced foam core sandwich structures with defects, a critical ability necessary for the utilization of 3DFRFC sandwich composites as primary structures for launch vehicles and spacecraft. This proposed research has the goals of developing, implementing, and validating a modeling technique that will address this need. The outcomes of this research will provide the critical understanding and engineering tools required to fully exploit the benefits of advanced three-dimensionally reinforced sandwich structures in current and future spacecraft and launch vehicles, while having transformative impacts to the ability to utilize advanced materials in commercial aerospace and non-aerospace applications.

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Space Technology Research Grants

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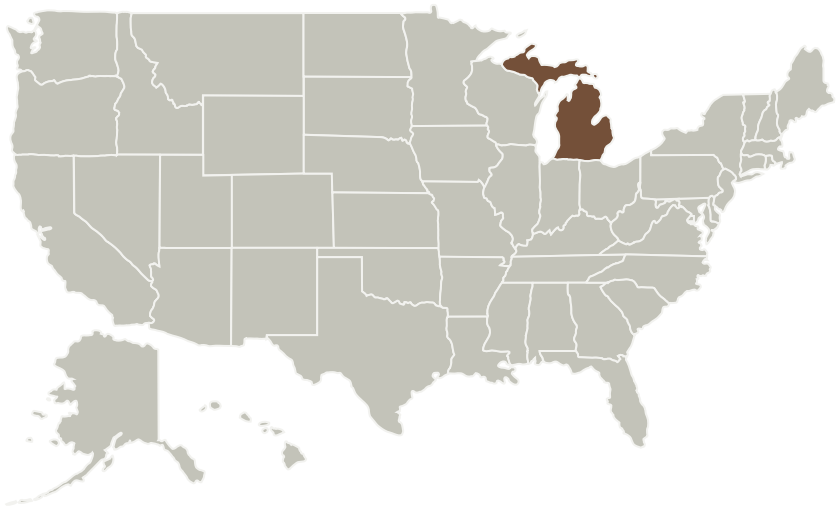
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Michigan-Ann Arbor	Supporting Organization	Academia	Ann Arbor, Michigan

Primary U.S. Work Locations
Michigan

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html

Project Management

Program Director:
Claudia M Meyer

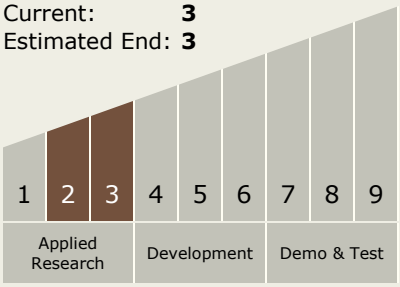
Program Manager:
Hung D Nguyen

Principal Investigator:
Veera Sundararaghavan

Co-Investigator:
Zachary T Kier

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - TX12.5 Structural Dynamics
    - TX12.5.4 Test, Tools, and Methods